



# Metabolomic profiles of tropical *Chlorella* species in response to physiological changes during nitrogen deprivation

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Received: 26 January 2018 / Revised and accepted: 2 May 2018  
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## Abstract

*Chlorella* species are known to be potential algal candidates for biodiesel production due to their ability to store lipids and their natural metabolic versatility. This study assessed the photosynthetic performance, biochemical composition, and metabolomic profiles of tropical *Chlorella* UMACC050 harvested from different growth phases in batch culture, grown under nitrogen-replete, and nitrogen-depleted conditions. Physiological data suggested that growth and photosynthetic efficiency were affected during nitrogen deprivation. Nitrogen deprivation resulted in a decrease in biomass productivity and an increase of lipid content. Nitrogen-depletion resulted in an increase in saturated fatty acids (SFA) and monounsaturated fatty acids (MUFA), especially C16:0, C18:0, and C18:1, at the expense of polyunsaturated fatty acids (PUFA). Changes in the metabolomic profiles suggested that there was nitrogen assimilation from proteins and photosynthetic machinery, together with repartitioning of carbon into carbohydrates and lipids in response to nitrogen depletion. Overall, our results expand the current understanding of metabolomics of *Chlorella* species and provide valuable insights into their lipid accumulation during nitrogen deprivation, which is important for optimization of lipid productivity in the tropical environment.

**Keywords** Algae · Biodiesel · Chlorophyta · *Chlorella* · Fatty acid · Nitrogen · Metabolomics

## Introduction

*Chlorella* has received much interest as a potential feedstock for industrial biomass production (Juntilla et al. 2015; Cen

et al. 2016), biodiesel (Huang et al. 2016; Nam et al. 2017), and value-added chemicals (Aremou et al. 2016). *Chlorella* species are among the best oil feedstock microorganisms for the production of biodiesel (Jian et al. 2015). According to Zhu et al. (2016), carbon overflow within the algal cell allows accumulation of a high percentage of neutral lipids that can be processed for biodiesel production. This can be achieved by manipulating the nitrogen concentration in the culture medium. Nitrogen deprivation induces cessation of cell division (cellular quiescence) (Merchant et al. 2012; Liu and Benning 2013; Tsai et al. 2014) and causes algae to produce substantial amounts of triacylglycerols (TAG), up to ~20 to 50% of dry weight (Hu et al. 2008). In *Chlorella*, nitrogen deficiency has been shown to reduce its growth and protein contents while promoting lipid accumulation (Illman et al. 2000; Ramazanov and Ramazanov 2006; Ördög et al. 2012). Ito et al. (2013) reported that under nitrogen stress condition, the quantities of neutral lipids in microalgal cells were greatly increased, while amino acid contents were significantly reduced to 1/20 of the amount or even less.

Metabolomics is the study of the metabolites within the cell to understand its biochemical processes. Previous studies suggest that enhanced lipid production under nitrogen deprivation

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**Electronic supplementary material** The online version of this article (<https://doi.org/10.1007/s10811-018-1504-4>) contains supplementary material, which is available to authorized users.

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